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(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Foil and Method of Making the Same

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ABSTRACT

A foil for use in connection with the wrapping of foodstuffs, cosmetics and other products has a plastic substrate one side of which is coated with a film of metallic material, such as aluminum. The exposed surface of the metallic film is provided with a thin protective layer which contains a wax, a resin, a lubricant and/or another organic material and shields the metallic film from scuffing, corrosion as well as from direct exposure to air and/or moisture. The metallic material of the film is vaporized onto the one side of the substrate, and the organic material of the protective layer is vaporized onto the exposed surface of the film in one or more stages as soon as the vaporization of metallic material upon an increment of the substrate is completed.

The invention relates to improvements in composite sheets in general (hereinafter called foils for short), and more particularly to improvements in foils wherein at least one side of a substrate (e.g., a strip or web of plastic material) is coated with a metallic film, such as a film of aluminum. The invention also relates to a method of making foils which contain metallic films.

Foils of the above outlined character are in widespread use in a number of industries, particularly for the packing or wrapping of foodstuffs and many other products. An advantage of foils which consist of or include metallized substrates is that they enhance the appearance of the packed or wrapped products. Another advantage of such foils is that their initial as well as processing cost is but a fraction of the cost of foils which are made solely of a metallic material, such as aluminum. A further important advantage of foils wherein a usually nonmetallic substrate carries one or more films of metallic material is that they can be provided with one or more additional coats in a simple, time-saving and inexpensive manner.

A drawback of presently known foils wherein a substrate carries one or more films of metallic material is that they are not suitable for a number of important uses. For example, foodstuffs of many kinds, as well as many cosmetic substances, must be packaged or wrapped in such a way that the contents of the package are reliably sealed from the surrounding air as well as from moisture. Heretofore known attempts to produce foils which satisfy such requirements include the utilization

of plastic substrates which are laminated with films of a metallic material, such as aluminum. It is also known to coat metallized plastic foils with layers of polyvinylidene chloride. A drawback of such foils is that they are expensive as well as that they do not satisfy the exacting requirements of environmental protection agencies in many countries. Another drawback of such foils is that they are not fluidtight, or are not sufficiently fluidtight, for a number of purposes. Moreover, their ability to prevent the penetration of gaseous and/or liquid fluids is not predictable and often varies from area to area. While the inability of such conventional foils to prevent the passage of certain gases and/or vaporized liquids might not be detrimental for a number of uses, their permeability to oxygen and/or vapors (such as water vapors) renders them unacceptable for a number of important applications in the food processing and many other industries. Extensive and costly research in this field has so far failed to provide a solution which would broaden the field of application of metallized foils. Moreover, the permeability of conventional foils to oxygen and to certain other fluids increases drastically if their metallic films are permitted to rub against each other and/or against the substrates and/or against the confined product or products.

One feature of the invention resides in the provision of a foil which comprises a substrate having a first side and a second side, a metallic film which adheres to at least one side of the substrate and has a surface facing away from the one side of the substrate,

and a protective layer which overlies and adheres to the entire surface of the film. The layer preferably contains or consists of an organic material which strongly adheres to the surface of the film. Such organic material can have a molecular weight of at least 10,000 kp or a molecular weight of less than 10,000 kp. The organic material can be selected from the group consisting of natural and synthetic resins, natural and synthetic waxes and lubricants. For example, the organic material can contain a resin for lacquers and varnishes, a nonsmearing wax or caoutchouc. Furthermore, the organic material can constitute a priming which facilitates the application of printed matter to the protective layer.

The layer is preferably thin, most preferably very thin. For example, the layer can have a thickness of 0.1 to 1 $g/m^2$. Such layer is preferably applied to the metallic film while the latter is still devoid of scratches and/or other defects which would render the film permeable to gases. For example, the metallic material of the film can be vaporized onto the one side of the substrate and the organic material of the protective layer can be vaporized onto successive increments of the freshly vaporized film.

The protective layer and the film can jointly constitute a fluidtight coating at the one side of the substrate. Furthermore, the layer can be resistant to corrosion, i.e., it can prevent oxidation of the metallic film.

The layer is preferably made in such a way that its thickness is constant along the entire surface

of the film. Furthermore, the protective layer can be resistant to blocking. The organic material of the layer preferably exhibits high affinity for the metallic material of the film, and the layer is preferably made of an imprintable material.

The foil can further include a coating which overlies and adheres to the protective layer. The coating can constitute an extrusion which is crystallized on and uniformly covers the layer.

It is further desirable to make the layer of a physiologically acceptable material and to utilize an odorless material.

The substrate can be made of a material which is selected from the group consisting of polypropylene, polyethylene, polyesters, polyamides, polystyrene and polyvinyl chloride.

The preferably thin layer is or can be made of a material which has a low coefficient of friction, i.e., which has a smooth exposed surface and can move relative to an abutting surface in response to the application of a relatively small force. The term "protective" is intended to denote, among others, that the layer can shield the surface of the metallic film from scuffing.

Another feature of the invention resides in the provision of a method of making a foil of the above outlined character. The method comprises the steps of applying a film of metallic material (e.g., aluminum) to at least one side of a substrate so that the film has a surface which faces away from the substrate, and bonding

a protective layer to the surface of the film. The layer can contain an organic material, and the bonding step can include vaporizing the organic material onto the surface of the film.

The method can further comprise the step of convoluting the foil upon completion of the bonding step. The applying step of such method can include vaporizing the metallic material onto the at least one side of the substrate, and the bonding step can include vaporizing the organic material onto the film immediately following the applying step. The organic material can be selected from the group consisting of natural and synthetic resins, natural and synthetic waxes and lubricants. The film is ready to withstand a force which is applied to it by way of the protective layer as soon as the making of the layer is completed.

The protective layer is preferably thin and its thickness is preferably constant along the entire surface of the film.

The applying step can include vaporizing the metallic material onto the at least one side of the substrate in a vaporizer, and the bonding step can include vaporizing the organic material of the layer onto the surface of the film while the respective portion of the substrate is still in the vaporizer. The organic material of the layer is preferably selected in such a way that it exhibits high affinity for the metallic material of the film.

If the layer contains a resin, the bonding step can include heating the resin to vaporization

temperature in a vaporizer and contacting the surface of the film with vaporized resin in the vaporizer.

The bonding step can include a plurality of successive stages. The method then preferably further comprises the step of advancing the substrate and the film thereon along a predetermined path, and each stage can include contacting the film with vaporized organic material in successive portions of the path. The contacting steps can include applying a discrete stratum of organic material to the film in each portion of the path so that the application of a next-following stratum begins immediately following completion of application of a preceding stratum. Such method preferably comprises the step of solidifying successively applied strata of the layer, and the contacting steps can include applying each next-following stratum subsequent to start of solidification of the immediately preceding stratum.

Successive stages of the bonding step can be carried out at predetermined intervals, preferably at intervals of 30 to 120 seconds. The duration of the intervals can depend upon the characteristics of the corresponding strata; alternatively, such intervals can be fixed or variable. The arrangement may be such that the duration of intervals increases or decreases from each preceding stage to the next-following stage of the plurality of successive stages. Each stage can involve the application of one and the same material to the film; alternatively, at least one stage can involve the application of a first material and at least one other stage can involve the application of a different second material to

the film. For example, one of the materials can be a resin and another material can be a wax. If the stages include three or more successive stages, the bonding step can include alternatingly applying resin and wax during successive stages of such plurality of successive stages.

A presently preferred embodiment of the method further comprises the step of advancing the substrate along a predetermined path in a predetermined direction and at a predetermined speed, and the applying step includes vaporizing the metallic material onto the at least one side of the advancing substrate at the predetermined speed and while the substrate advances along a first portion of its path. The bonding step comprises establishing a supply of organic material adjacent a second portion of the path downstream of the first portion, heating the supply to vaporization temperature, and contacting the film with vaporized organic material in the second portion of the path. The heating step can include electrically heating the supply of organic material.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved foil itself, both as to its composition and the method of making the same, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain presently preferred specific embodiments with reference to the accompanying drawing.

FIG. 1 is an enlarged fragmentary sectional view

of a foil which embodies one form of the invention and comprises a single metallic film and a single protective layer for the metallic film;

FIG. 2 is a greatly enlarged view of a detail in FIG. 1;

FIG. 3 is an enlarged view similar to that of FIG. 2 and further showing printed matter applied to the exposed side of the protective layer;

FIG. 4 shows the application of an extruded coating to the exposed side of the protective layer;

FIG. 5 is a fragmentary sectional view of two convolutions of the improved foil on a core;

FIG. 6 is a diagrammatic view of an apparatus which can be utilized for the practice of the improved method; and

FIG. 7 is an enlarged fragmentary sectional view of that portion of the apparatus which is indicated by the arrow VII, the section being taken in a plane which is parallel to the plane of FIG. 6 and being turned through 180°.

Referring first to FIGS. 1 and 2, there is shown a portion of a foil which includes a plastic carrier or substrate 1, a metallic film 2 which adheres to one side 5 of the substrate and has a surface 6 which faces away from the substrate, and a thin protective layer 3 which adheres to and overlies the entire surface 6 of the film 2. The metallic material of the film 2 is vaporized, sprayed or otherwise applied to the adjacent side 5 of the substrate 1. The organic material of the protective layer 3 can be vaporized onto or otherwise

applied to the surface 6 so that the finished layer 3 shields the metallic film 2 from corrosion, mechanical damage and other undesirable influences.

Certain presently preferred materials for the making of the protective layer 3 include natural and synthetic resins, natural and synthetic waxes and certain friction reducing agents (hereinafter called lubricants). For example, the material of the layer 3 can be a synthetic resin for lacquers and varnishes. It is also possible to utilize caoutchouc, a mixture of natural and synthetic resins, a mixture of natural and synthetic waxes or any other mixture of the above-enumerated organic substances (for example, a mixture of a natural or synthetic resin with a natural or synthetic wax).

It is important to ensure that the protective layer 3 be bonded to the surface 6 of the metallic film 2 while the film is still intact, i.e., while the film is still devoid of scratches, scuffs and/or other mechanical defects. This can be readily achieved if the layer 3 is formed immediately or practically immediately following the application of metallic material of the film 2 to the respective side 5 of the substrate 1. One presently preferred mode of forming the layer 3 will be described with reference to FIGS. 6 and 7. It is presently preferred to vaporize the organic material of the layer 3 and to contact successive increments of the surface 6 of the freshly formed film 2 with vapors. As a rule, it is desirable to provide the foil with a thin or extremely thin layer 3 which is preferably of uniform thickness

adjacent each and every portion of the surface 6. Such uniform thickness can be readily achieved by appropriate control of vaporization of a supply of organic material and by appropriate control of the establishment of contact between the vaporized organic material and the surface 6 of the film 2. Another advantage of bonding of the layer 3 by contacting the film 2 with vaporized organic material is that the density of the thus obtained layer is high which is desirable in many instances, for example, if the layer 3 is to constitute a barrier against penetration of oxygen and/or vapors into contact with the metallic material of the film 2. Moreover, a dense layer 3 can shield the film 2 from scuffing, scratching and/or other undesirable mechanical influences.

In many instances, an intact metallic film 2 is impermeable to fluids (such as air, water and vapors). Thus, if the film 2 is intact prior to the application of the protective layer 3, it will remain intact even if the layer 3 is permeable to fluids. However, the material of the layer 3 can be readily selected in such a way that the combination of intact film 2 and protective layer invariably prevents penetration of any fluids toward and into contact with the substrate 1 and hence into contact with the material or materials which are to be confined by the improved foil. Therefore, the improved foil can be utilized with advantage for the wrapping or packing of certain types of foodstuffs and cosmetics which should be reliably sealed from oxygen and/or water vapors or which should not be relieved of moisture.

The material of the layer 3 can be selected with

a view to satisfy all of the above enumerated requirements as well as to form a strong mechanical barrier adjacent the surface 6 of the film 2. This renders it possible to apply to the film 2 a pronounced force, as long as such force is applied by way of the protective layer 3. Moreover, the layer 3 preferably exhibits a pronounced resistance to blocking so that it does not adhere to an adjacent layer 3 or to the uncoated side of a substrate 1 even if it is acted upon by a considerable force which tends to urge it toward the surface of the film 2.

It is important to select a material which can be vaporized at temperatures below that temperature or below that range of temperatures which could affect the quality of the film 2 and/or substrate 1. Thus, if the material of the layer 3 is to be applied to the surface 6 of the film 2 in vaporized state, the material is preferably vaporizable at temperatures between approximately 100°C. and 150°C. The vaporized material deposits and is condensed on the surface 6 of the film 2. A single stratum of vaporized and condensed material often suffices to form a reliable protective layer 3 which is not permeable to oxygen and/or vapors, either alone or jointly with the metallic film 2. However, and as will be explained with reference to FIGS. 6 and 7, the protective layer 3 can consist of two, three or more superimposed strata which are applied in a series of successive stages. Such mode of forming the layer 3 is particularly desirable if successively applied strata of the layer consist, at least in part, of different materials each of which is to enhance a particular characteristic of the finished product.

A material which is a proper combination of two or more different substances can serve as a corrosion preventing or retarding barrier in front of the surface 6 of the metallic film 2. Thus, the material of the layer 3 can be selected to prevent penetration of oxygen and/or vapors toward and into contact with the surface 6 so that the metallic film 2 can merely serve as a reinforcement for the substrate 1 and/or as a decorative part of the foil because the protective layer 3 is capable of intercepting oxygen and/or vapors so that these substances cannot reach the surface 6. Such protective layer can be formed by using a selected natural or synthetic resin, a selected natural or synthetic wax or a combination of two or more natural or synthetic resins and/or waxes. The ability to prevent corrosion of the film 2 is an important characteristic of the protective layer 3. Extensive experiments indicate that the ability of a metallic film to resist penetration of oxygen and/or vapors is greatly affected by corrosion, i.e., corrosion contributes to or causes permeability of the metallic film.

A distinguishing feature of resins is that their molecular weight is not less than 10,000 kp whereas the molecular weight of waxes is less than 10,000 kp. If the protective layer 3 is a mixture of one or more waxes and one or more resins, the resin or resins enhance the resistance of the layer 3 to scuffing and/or other mechanical stresses (such resistance increases if the molecular weight of the selected resin or resins is higher). On the other hand, the wax or waxes in such mixture enhance the flexibility (suppleness) of the protective

layer 3. Selection of one or more materials which are to constitute or to form part of the protective layer 3 further depends upon the intended use of the foil. For example, the ratio of natural and synthetic waxes and/or resins will be selected in dependency upon the desired or expected resistance of the layer 3 (or a combination of film 2 and layer 3) to penetration of one or more particular gases and/or vapors as well as in dependency on the environment in which the foil is to be put to use.

In addition to containing one or more aforementioned materials (such as natural and/or synthetic waxes and/or natural and/or synthetic resins), the protective layer 3 can also contain one or more friction reducing substances which act as lubricants. The addition of one or more lubricants enables the exposed surface of the protective layer 3 to readily slide along the exposed surface of a neighboring layer 3 or along the uncoated side of a substrate 1 or along the adjacent surface of a product which is to be packed or wrapped. FIGS. 5 and 6 show a roll 18 of convoluted foil wherein the exposed surface of the protective layer 3 forming part of an inner convolution is in contact with the uncoated side of the substrate 1 forming part of the neighboring outer convolution. The addition of one or more lubricants ensures that the layer 3 is not damaged as a result of sliding contact with the adjacent substrate 1. The innermost convolution of the roll 18 surrounds a core 8.

The lubricant is selected in such a way that it does not promote the separability of the layer 3 from the surface 6 of the metallic film 2; on the contrary, the

selected lubrican or lubricants can enhance the ability of the layer 3 to strongly adhere to the film 2. Moreover, the selected lubricant can enhance the afore-discussed desirable characteristics of the protective layer 3, such as flexibility, resistance to penetration of oxygen and/or vapors, mechanical strength and/or others. The percentage of lubricant in the layer 3 is or can be small so that the addition of lubricant does not contribute to thickness of the layer to any significant extent. The lubricant can but need not constitute the outermost stratum of a protective layer 3 which consists of two or more superimposed strata.

Another advantage of a lubricant is that it enables the thus obtained protective layer 3 to constitute a highly satisfactory priming which enhances the ability of the foil to accept and retain printed matter. This is shown in FIG. 3 wherein the exposed surface 3a of the protective layer 3 carries printed matter 3b. FIGS. 1, 2 and 3 further show that the ratio of thicknesses of the metallic film 2 and protective layer 3 need not be fixed. Thus, the thickness of the layer 3 in FIG. 1 matches or approximates the thickness of the metallic film 2. On the other hand, the metallic film 2 which is shown in FIGS. 2 and 3 is thicker than the protective layer 3.

The presence of lubricant in the protective layer 3 is often desirable on the additional ground that such protective layer can be more readily bonded to a coating 3c of extruded plastic or other material (see FIG. 4). FIG. 4 further shows that the abutting surfaces of the film 2 and layer 3 can form a number of hills and

valleys 7.

As already mentioned above, the protective layer 3 can be selected and bonded to the film 2 with a view to prevent corrosion of the metallic material of the foil. The material of the layer 3 can be selected with a view to prevent corrosion of the film 2 for any desired interval of time, as long as the layer 3 remains at least substantially intact. The constituent or constituents of the layer 3 can be selected with a view to constitute an anticorrosion barrier for a particular metallic material as well as in dependency upon the intended use of the foil and in dependency upon the anticipated mechanical and/or other stressing of the layer 3 in actual use of the foil. The lubricant or lubricants in the layer 3 can be selected in such a way that they do not affect the ability of the layer 3 to prevent corrosion of the metallic film 2; on the contrary, certain lubricants can enhance such ability of the protective layer.

Still further, the material of the protective layer 3 is preferably selected in such a way that it exhibits high affinity for the metallic material of the film 2. Thus, and if the material of the layer 3 is vaporized prior to contacting the surface 6 of the film 2, the vaporized material should exhibit pronounced affinity for the metallic material to thus ensure the establishment of a reliable and lasting bond which will remain intact in actual use of the foil. Moreover, such affinity ensures that the layer 3 overlies and adheres to the entire surface 6 of the metallic film 2 so that the quality of each and every portion of the finished product

is equally satisfactory. In addition, such selection of the material of the layer 3 ensures or contributes to uniform application of vaporized material of the layer 3 to the surface 6 of the film 2.

It is further desirable to select the material of the protective layer 3 with a view to ensure that the surface 3a (FIG.3) of the finished layer can readily accept and retain printed matter 3b which is applied in accordance with available printing techniques. This can be readily achieved if the material of the layer 3 contains one or more organic substances of the above enumerated character, such as one or more natural and/or synthetic resins and/or one or more natural and/or synthetic waxes with or without one or more lubricants. As mentioned above, a properly composed protective layer 3 can serve as a highly satisfactory priming for the printed matter 3b. This renders it possible to dispense with the application of a priming to the exposed surface 3a of the protective layer 3 prior to the application of printed matter 3b. A protective layer 3 can serve as a satisfactory priming for printed matter 3b and/or as an adhesion-promoting substrate for the extruded coating 3c of FIG. 4. Such selection of the protective layer 3 (to serve as a priming for printed matter 3b and/or for the coating 3c) enhances the versatility of the foil and reduces its cost because it is not necessary to apply a specially produced priming over the surface 3a of the layer 3. It has been found that low-molecular olefin waxes are particularly suitable for use in a protective layer 3 which is to serve as an adhesion-promoting priming

for an extruded coating 3c.

Still further, the material of the protective layer 3 can be selected with a view to ensure that its surface 3a will accept and retain an adhesive or a solvent which is to be applied preparatory to the making of a laminate including the improved foil and one or more additional sheet-, strip- or web-like materials which are to be bonded to the layer 3. Moreover, the material of the extruded coating 3c should be capable of satisfactory crystallization on the surface 3a of the layer 3. Polyethylene and polypropylene constitute satisfactory substrates for a polyolefine coextrusion.

The material of the protective layer 3 is preferably selected with a view to ensure that it is physiologically acceptable and that it is preferably odorless. Thus, the material of the layer 3 should not affect the quality of the products which are to be wrapped or packed in the improved foil, and such material should not be harmful to human beings and/or animals.

The substrate 1 can be made of a wide variety of materials. Certain presently preferred materials include polypropylene, polyethylene, polyesters, polyamides, polystyrene and polyvinyl chloride.

The layer 3 is preferably thin; its thickness can be in the range of 0.5 to 1 $g/m^2$.

FIGS. 6 and 7 show certain parts of a presently preferred apparatus which can be utilized for the practice of the improved method, i.e., for the making of the improved foil. An organic material 22 (which can be a natural or

synthetic wax, a natural or synthetic resin, each with or without a lubricant, or any combination of such materials at a desired ratio) is fed into a vaporizer 19 wherein a heated wall 25 surrounds a bath 23 of organic material 22. The wall 25 is formed with a slot or outlet 24 which enables vapors of organic material 22 to contact successive increments of the film 2 at the underside of a substrate 1 which is advanced in the direction of arrow from a source 13 to the station for the roll 18 of convoluted foil. The vaporizer 19 is installed in a vaporizing unit 9 for metallic material which is to form the film 2. The inlet to the unit 9 is shown at 14, the peripheral surface of a rotary back support 15 for the uncoated side of the substrate 1 is shown at 16, and the character 17 denotes a guide for the substrate 1 and ~~film 2 during advancement past the vaporizer 19 and a~~ second vaporizer 35 downstream of the vaporizer 19. The back support 15 and the guide 17 are installed in the internal chamber 10 of the vaporizing unit 9, and the reference characters 11 and 12 denote standard parts of the unit 9, i.e., of the means for applying the metallic film 2 to successive increments of the underside of the substrate 1 which is advanced at a predetermined speed, namely at a speed which is required to form a film 2 of acceptable quality.

The guide 17 ensures that successive increments of the freshly formed film 2 advance past the slot 24 of the wall 25 which is heated by an electric heating element 26 in circuit with an energy source 20 to ensure that the organic material which enters the internal space 34 of

the wall 25 at the inlet 28 of a replenishing device 33 is vaporized to an extent which is necessary to provide the surface 6 of the metallic film 2 with a layer 3 of requisite thickness. The cloud or flow of vapors issuing from the internal space 34 of the wall 25 through the slot 24 is shown at 21, and such vapors condense on the surface 6 of the metallic film 2 to form the protective layer 3. The thickness of the layer 3 depends on a plurality of parameters, such as the composition of the bath 23, the rate at which the bath 23 is heated by the heating element 26 (through the medium of the wall 25), the speed of advancement of the substrate 1 from the source 13 toward the roll 18 of convoluted foil, the rate at which the organic material 22 is fed into the bath 23, and others. The rate of feed of organic material 23 and the rate of evaporation of such material in the internal space 34 of the wall 25 are related to the speed of advancement of the substrate 1 and film 2 in order to ensure the formation of a protective layer 3 which has a required thickness and covers the entire surface 6 of the film 2. On the other hand, the speed of movement of the substrate 1 from the source 13 toward the roll 18 depends on the desired thickness of the film 2 which is applied between the back support 15 and the parts 11, 12 of the vaporizing unit 9.

The heating element 26 is designed to heat the wall 25 which, in turn, heats the organic material 22 in the internal space 34 to a temperature above the boiling or melting point so that the bath 23 discharges vapors which rise into the slot 24 in the form of a flow or cloud

21 and are converted into the protective layer 3.

FIG. 6 further shows that the layer 3 can be applied in several successive stages, i.e., such layer can consist of two or more strata one of which overlies the surface 6 of the film 2 and each other of which overlies the previously applied stratum. The second vaporizer 35 is located immediately or closely downstream of the vaporizer 19, and the vaporizer 35 can be followed by one or more additional vaporizers (not shown), depending on the desired number of strata in the layer 3 of the foil which forms the roll 18. The vaporizer 35 receives an organic material 38 which is or which can be different from the organic material 22. The arrangement can be such that the organic material 22 consists of or contains one or more natural and/or synthetic resins whereas the organic material 38 consists of or contains one or more natural and/or synthetic waxes. Alternatively, each of the organic materials 22, 38 can consist of or contain one or more natural and/or synthetic waxes or one or more natural and/or synthetic resins, i.e., the composition of the material 22 can be the same as that of the material 38. The stratum which is applied by the vaporizer 35 is shown at 39. The reference character 36 denotes in FIG. 6 the energy source for the electric heater of the vaporizer 35, and the character 37 denotes the cloud or flow of vapors which are discharged by the vaporizer 35 to form the stratum 39. It is clear that the vaporizers 19 and 35 can employ a common energy source 20 or 36; in fact, the vaporizer 35 can be identical with the vaporizer 19, and the same applies for one or more additional vaporizers

(if used) downstream of the vaporizer 35. If the apparatus of FIG. 6 employs three or more vaporizers, the first, third, etc. vaporizers can receive vaporizable material of a first composition, and the second, fourth, etc. vaporizers can receive vaporizable material of a different second composition.

It is often desirable to place the vaporizers 19 and 35 into close or immediate proximity to each other. This might be desirable and advantageous if the vapors 37 are to contact the material of the preceding stratum before the material of the preceding stratum sets, i.e., the materials which are applied by the vaporizers 19 and 35 can be caused or permitted to mix and to form a layer 3 which has been produced in several successive stages but its composition is at least substantially homogeneous all the way between the surface 6 of the film 2 and the exposed surface 3a of the finished protective layer. Such layer can serve as a fluidtight barrier against penetration of oxygen and/or vapors into contact with the metallic film 2.

The distance of successive vaporizers from each other will depend on the desired nature of the protective layer 3. Thus, if such layer is to be composed of two or more discrete superimposed strata (such as the stratum 39 in FIG. 6), the distance of neighboring vaporizers from each other will be increased to lengthen the intervals between the application of successive vaporized organic materials. The length of such intervals can vary between, for example, 30 and 120 seconds. The length of intervals will also depend upon the nature of

vaporized materials and can be constant from vaporizer to vaporizer or variable, e.g., by increasing or reducing the speed of advancement of the substrate 1 and metallic film 2.

The present invention is based on the recognition that a metallic film which is applied to a substrate is subjected to friction practically immediately following the application of such film to the substrate because, as a rule, the thus obtained foil is rolled onto a core or the like as soon as the application of the metallic film is completed. The neighboring convolutions of a roll 18 of convolutions forming part of a rolled up foil rub against each other and, in the absence of any remedial action, the exposed surface of the metallic film bears against the adjacent side of the substrate, against the adjacent surface of a metallic film or against the surface of a product to be packed or wrapped. Shifting of neighboring convolutions relative to each other can result in a minute displacement in the range of one or more tenths of one millimeter; however, such minor displacements suffice to affect the integrity of the metallic film, i.e., the film is likely to be scuffed and/or otherwise adversely influenced and to thus suffer damage which affects its resistance to penetration of oxygen and/or vapors and/or other desirable characteristics. The quality of the metallic film is or can be affected regardless of whether the film is caused to contact another metallic film, the substrate or any other material. The damage to metallic film is or can be minute so that it can be ascertained only as a result of inspection with a

microscope; however, such minute damage often suffices to greatly affect certain desirable characteristics of the foil, particularly the ability of the metallic film to prevent the penetration of oxygen and/or vapors therethrough. The exact reasons for an often pronounced drop of impermeability of the metallic film, even in response to minute shifting of neighboring convolutions of a rolled up foil (namely a shifting in the range of one or more tenths of one millimeter) are still unknown. However, it is known that the extent of impermeability or lack of permeability of the metallic film is a function of several parameters including the extent of shifting of neighboring convolutions of the roll of foil relative to each other, the tensional stress upon the convolutions, the diameter of the roll, the roughness of the surface which is in contact with the exposed surface of the metallic film, and certain other factors such as the temperature of vaporized metallic material which is being applied to a substrate, the speed of forward movement of the substrate and the speed of convoluting the metallized substrate onto a core or the like.

The metallic film on a substrate can be damaged during rolling of the foil onto a core as well as during unwinding of the foil and/or during other processing of the normally convoluted foil, e.g., while the foil is being severed into sections of desired size and/or shape. Surprisingly enough, experiments with foils consisting of metallized substrates indicate that the permeability of the metallic film is not dependent upon the thickness of such film.

Heretofore known attempts to reduce the proneness of a foil, wherein a substrate carries a metallic film, to damage as a result of rubbing of the exposed surface of the metallic film against an adjacent surface include the utilization of a friction reducing layer which is applied to the exposed surface of the metallic film. Such experiments have met with quite satisfactory results if the friction reducing layer was applied to the exposed surface of the metallic film prior to conversion of a freshly metallized substrate (i.e., a foil) into a roll of superimposed convolutions. Reference may be had to commonly owned U.S. Pat. No. 4,818,609 granted April 4, 1989 for "Packaging comprising substrate metallic layer and antifriction film". However, such foils also exhibit a number of serious drawbacks. For example, the friction reducing layers of presently known composition contribute significantly to the overall thickness of the foil. The reason is that heretofore known materials which are used to make friction reducing coatings cannot be applied in a manner to ensure that they do not significantly increase the thickness of the foil, i.e., the combined thickness of a substrate, a metallic film and a friction reducing layer or coating. This prevents the thus obtained foil from being utilized in a number of fields, particularly in connection with the wrapping or packing of certain foodstuffs and/or cosmetics. Moreover, heretofore known layers which are intended to reduce friction between neighboring layers of a foil and/or between a foil and a material to be packed or wrapped are not capable of ensuring convenient application of printed matter by

resorting to heretofore known printing procedures. The same applies when a foil which is provided with a conventional friction reducing layer is to be laminated with a further foil or with any other sheet-, web- or strip-like material and/or when a coating is to be extruded onto the friction reducing layer. Therefore, the makers of metallized substrates often desist from utilizing a friction reducing layer on top of the metallic film in spite of the aforediscussed advantages of such layers. The reason is that the application of a conventional friction reducing layer limits the fields of application of the foils and also that the application of a conventional friction reducing layer contributes significantly to the cost of the foil. The cost is increased because it is very difficult to control the application of a conventional friction reducing layer in such a way that the layer does not contribute significantly to the thickness of the thus obtained foil. Moreover, if the thickness of the friction reducing layer exceeds a certain value, the layer is likely to peel off the adjacent surface of the metallic film so that the metallic film is exposed to the action of oxygen, water vapors and/or other undesirable influences.

The improved foil exhibits a number of important advantages. Thus, the protective layer 3 shields the metallic film 2 even before the web or strip including the substrate 1 and the metallic film 2 is converted into a roll 18, and the layer 3 also protects the film 2 during each and every stage of unwinding of the foil from the roll 18, during subdivision of the foil into

sections of desired size and/or shape as well as in actual use as a packaging, wrapping or like material. The film 2 is protected from scuffing, chafing and/or other mechanical damage, and its flexibility is not affected by the protective layer since the latter can be more readily flexible than the film 2 and/or the substrate 1. The film 2 remains impermeable to fluids, either because it is shielded from mechanical damage or because its resistance to penetration of gases and/or other fluids is enhanced by the protective layer 3.

Another important advantage of the improved foil is that the material of the protective layer 3 can be readily selected and applied in such a way that the layer exhibits no tendency to become separated from the metallic film 2, even if the thickness of the layer matches or exceeds the thickness of the film. Since the flexibility of the layer 3 can be determined in advance by appropriate selection of the material or materials which are to be bonded to the surface 6 of the metallic film, the finished foil can exhibit a desired flexibility which is best suited for unwinding from the roll 18, for severing and/or for conversion into packages of desired size and/or shape.

Still further, the metallic film 2 can remain intact for any desired period of time because it is not subjected to the corrosive action of oxygen and/or vapors. All that is necessary is to ensure that the protective layer 3 is applied before the exposed surface 6 of the metallic film 2 is subjected to any rubbing, scuffing, grinding or other mechanical action which would be likely

to render it permeable to fluids. In fact, if the layer 3 is applied before the foil is converted into a roll 18, the layer 3 contributes to a reduction of friction between neighboring convolutions of the roll 18 so that the likelihood of excessive mechanical stressing of the film 2 and/or of the layer 3 is even more remote. Moreover, and since the layer 3 strongly adheres to the surface of the metallic film 2, even pronounced pressures between neighboring convolutions of the roll 18 cannot result in separation of the layer from the film and/or in mechanical damage to the layer and/or film. This holes true even if the protective layer is extremely thin, e.g., in the range of one or more hundredths of one micron. The provision of a relatively thin protective layer is desirable and advantageous in many or most instances ~~because this entails savings in the material of the~~ protective layer, a reduction of the thickness of the foil and a reduction of the dimensions of the roll 18. The nature of the method of bonding the layer 3 to the surface 6 of the metallic foil 2 can be readily selected in such a way that it is not even necessary to continuously monitor the thickness of the applied protective layer. This, too, contributes to simplicity and lower cost of the improved method and apparatus as well as to lower cost of the finished product.

Though it is possible to make the protective layer of a material other than an organic material, organic materials (including the above-enumerated waxes, resins and lubricants) are preferred at this time because such organic materials are relatively inexpensive, they

can be selected to exhibit pronounced affinity for the metal of the film 2, and they are effective as protective layers even if their thickness is minimal. Moreover, it is not necessary to monitor the application of protective layer to the film 2 with a high degree of accuracy because, though it is preferred to apply a protective layer of predetermined constant thickness, fluctuations of the thickness of the protective layer are of no great importance as long as the layer covers the entire surface 6 of the metallic film 2.

The utilization of a lubricant as a constituent of the material of the protective layer 3 constitutes an optional but often highly desirable and advantageous feature of the improved method and of the improved foil. However, care should be taken to ensure that the protective layer 3 which contains a lubricant will not exhibit the drawbacks of aforediscussed friction reducing layers which are utilized on the metallic films of certain conventional foils. Thus, the lubricant should be selected in such a way that it does not tend to smear the surface of an adjacent foil, metallic film or product to be wrapped or packed. Lubricants which are applied directly to the metallic films of conventional metallized substrates often exhibit a pronounced tendency to smearing. Lubricants which are present in the protective layer 3 can be readily distributed in the other material or materials of the layer 3 in such a way that they can perform their friction reducing function but are incapable of smearing the surfaces of adjacent foils and/or other parts. In fact, the aforementioned organic

materials of the protective layer 3 (including natural and synthetic resins and/or natural and synthetic waxes) often exhibit highly satisfactory friction reducing characteristics so that the utilization of a typical lubricant (i.e., of a substance which is to be utilized solely on account of its friction reducing characteristics) can be dispensed with.

The protective layer 3 is capable of taking up all mechanical and/or other stresses which are applied directly to the metallic films of many heretofore known foils. This contributes significantly to the useful life as well as to impermeability and/or other desirable characteristics of the metallic foil. Furthermore, the protective layer 3 prevents direct contact between the metallic foil 2 and the product or products to be packed, wrapped and/or otherwise protected by the improved foil, a feature which is often highly desirable and advantageous, for example, when the improved foil is to contact a substance containing acids or other ingredients which are likely to attack the metallic film.

The toughness of the protective layer 3, including the resistance to scratching, tearing, scuffing and/or other influences can be selected practically at will by the simple expedient of selecting the thickness and/or the composition of the protective layer. It has been found that a protective layer 3 which contains or consists of an artificial resin is especially suited to ensure the establishment of a highly reliable intimate bond between the protective layer and the surface 6 of the metallic film 2. On the other hand, a protective layer which contains

one or more natural resins can be used with particular advantage when the improved foil is to be employed as a packing or wrapping material for foodstuffs; such protective layers exhibit a highly satisfactory flexibility and a highly satisfactory resistance to scuffing and other undesirable mechanical influences.

The lubricants which are to be utilized as constituents of the protective layer can include various oils, greases, graphite and/or others. These lubricants can be selected in such a way that they reduce friction between the layer 3 and a neighboring layer as well as that they contribute to the corrosion-preventing or corrosion-reducing characteristics of the protective layer.

As mentioned above, the metallic film 2 can be applied to the substrate 1, and the protective layer 3 can be bonded to the surface 6 of the metallic film 2, in any well known manner as long as the selected procedures ensure proper adherence of the film to the substrate and to the protective layer. Vaporization of metallic material preparatory to making of the film 2, and vaporization of the material or materials of the protective layer prior to bonding to the surface 6 of the film 2 are preferred at this time because they permit simple, inexpensive and reliable regulation of the thickness of the film 2 and of the layer 3 as well as proper adherence of the film to the substrate and proper bonding of the layer 3 to the metallic film. All that is necessary is to control the speed of advancement of the substrate 1 past the metallizing station and to control the temperature and/or other parameters of the material

or materials which are to form the protective layer 3.

The lubricant in the protective layer of the improved foil can be the same as that disclosed in the aforementioned commonly owned U.S. Pat. No. 4,818,609, and the methods of bonding the protective layer 3 to the surface 6 of the metallic film 2 can be the same as those discussed in the aforementioned commonly owned patent for the application of antifriction film to the metallic layer.

EXAMPLE 1

A substrate of polyethylene was provided with a film of aluminum in a standard vaporizing unit. A vaporizer (such as 19) was used in the vaporizing unit for metallic material to apply a protective layer to successive increments of the freshly formed metallic film. The material of the protective layer was a readily meltable resin which was heated in the vaporizer to a temperature of 210°C. This resulted in the development of vapors which were directed against the exposed surface of the metallic film. Condensation of such vapors on the film resulted in the development of a protective layer with a thickness of 0.05 µ. The resin was of the type known as PENTALYN 255 which is produced by Hercules Inc., Wilmington, Delaware. The thickness of the protective layer was uniform, and such layer covered the entire exposed surface of the metallic film, i.e., that surface which faces away from the substrate. Cooling of the vapors on the surface of the metallic film was rapid, practically instantaneous, so that the thus obtained foil was ready for conversion into a roll of superimposed convolutions without

in any way affecting the integrity of the protective layer.

EXAMPLE 2

A running substrate of polyethylene was provided with a film of aluminum at a customary temperature and pressure. The application of metallic film was immediately followed by the application of vaporized organic material, namely a resin known as PEXIGRUM M 527 which is produced and sold by Röhm GmbH, Darmstadt, Federal Republic Germany. The organic material was heated to a temperature of 235°C and the thus developed vapors were caused to contact the exposed surface of the aluminum film. The thus obtained protective layer adhered firmly to the aluminum film and had the thickness of approximately 0.04 µ. The hardness of the protective layer was sufficient to permit conversion of the foil into a roll immediately following the formation of the protective layer.

EXAMPLE 3

A substrate of polyester was provided with a film of aluminum in a vaporizing unit at a customary temperature and pressure. A protective layer of organic material was bonded to the exposed surface of the aluminum film immediately after completion of application of aluminum to one side of the substrate. The organic material was a mixture of a resin of the type known as HALLOLYN 104 which is produced by Hercules Inc., Wilmington, Delaware and a wax known as E-Wachs 20R 6149 produced by BASF. The ratio of resin to wax in the material which was used to form the protective layer was approximately nine-to-one. The two ingredients were mixed in a single vaporizer and were heated to vaporization temperature to

develop vapors which were contacted by successive increments of the freshly applied aluminum film. The flexibility of the protective layer containing HALLOLYN 104 and E-Wachs 20R was improved by applying first a stratum of wax in a first vaporizer directly onto the aluminum film and by thereupon applying in a second vaporizer a second stratum of resin over the stratum of wax. The second stratum was applied prior to complete setting of the material of the stratum of wax.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A foil comprising a substrate having a first side and a second side; a metallic film adhering to at least one of said sides and having a surface facing away from said one side; and a protective layer overlying and adhering to the entire surface of said film.

2. The foil of claim 1, wherein said layer contains an organic material which strongly adheres to the surface of said film.

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3. The foil of claim 2, wherein said organic material has a molecular weight of at least 10,000 kp.

4. The foil of claim 1, wherein said organic material has a molecular weight below 10,000 kp.

5. The foil of claim 2, wherein said organic material is selected from the group consisting of natural and synthetic resins, natural and synthetic waxes and lubricants.

6. The foil of claim 5, wherein said organic material contains a resin for lacquers and varnishes.

7. The foil of claim 5, wherein said organic material contains a non-smearing wax.

8. The foil of claim 5, wherein said organic material contains caoutchouc.

9. The foil of claim 2, wherein said organic material is a priming which facilitates the application of printed matter to said layer.

10. The foil of claim 1, wherein said layer is thin.

11. The foil of claim 10, wherein said layer has a thickness of 0.5-1 $g/m^2$.

12. The foil of claim 1, wherein said film is at least substantially devoid of scratches.

13. The foil of claim 1, wherein said layer is vaporized onto the surface of said film.

14. The foil of claim 1, wherein said layer and said film together constitute a fluidtight coating at the one side of said substrate.

15. The foil of claim 1, wherein said layer is corrosion resistant.

16. The foil of claim 1, wherein said layer has a constant thickness along the entire surface of said film.

17. The foil of claim 1, wherein said layer is resistant to blocking.

18. The foil of claim 1, wherein said layer consists of a material which exhibits a high affinity for the metal of said film.

19. The foil of claim 1, wherein said layer consists of an imprintable material.

20. The foil of claim 1, further comprising a coating which overlies and adheres to said layer.

21. The foil of claim 20, wherein said coating is an extrusion which is crystallized on and uniformly covers said layer.

22. The foil of claim 1, wherein said layer consists of physiologically acceptable material.

23. The foil of claim 1, wherein said layer is odorless.

24. The foil of claim 1, wherein said substrate consists of a material selected from the group consisting of polypropylene, polyethylene, polyesters, polyamides, polystyrene and polyvinyl chloride.

25. The foil of claim 1, wherein said layer is thin and has a low coefficient of friction.

26. The foil of claim 1, wherein said layer shields the surface of said film from scuffing.

27. A method of making a foil, comprising the steps of applying a film of metallic material to at least at one side of a substrate so that the film has a surface facing away from the substrate; and bonding a protective layer to the surface of said film.

28. The method of claim 27, wherein said layer contains an organic material and said bonding step includes vaporizing the organic material onto the surface of said film.

29. The method of claim 27, wherein said layer contains an organic material and further comprising the step of convoluting the foil upon completion of said bonding step, said applying step including vaporizing the metallic material onto the at least one side of said substrate and said bonding step including vaporizing the organic material onto the film immediately following said applying step.

30. The method of claim 29, wherein said layer contains an organic material selected from the group consisting of natural and synthetic resins, natural and synthetic waxes and lubricants.

31. The method of claim 27, further comprising the step of exerting against said film a force by way of said layer.

32. The method of claim 27, wherein said layer is thin.

33. The method of claim 32, wherein said layer contains an organic material and has a constant thickness along the entire surface of said film.

34. The method of claim 27, wherein said applying step includes vaporizing the metallic material onto the at least one side of said substrate in a vaporizer, said layer containing an organic material and said bonding step including vaporizing the organic material onto the surface of the film in the vaporizer.

35. The method of claim 27, wherein said layer contains an organic material having a high affinity for the metallic material of said film.

36. The method of claim 27, wherein said layer contains a resin, said bonding step including heating the resin to vaporization temperature in a vaporizer and contacting the surface of the film with vaporized resin in the vaporizer.

37. The method of claim 27, wherein said bonding step includes a plurality of successive stages.

38. The method of claim 37, wherein the layer contains a vaporizable organic material and further comprising the step of advancing the substrate and the film thereon along a predetermined path, each of said stages including contacting the film with vaporized organic material in successive portions of said path.

39. The method of claim 38, wherein said contacting steps include applying a discrete stratum of organic material to the film in each portion of said path so that the application of a next following stratum begins immediately following completion of application of a preceding stratum.

40. The method of claim 39, further comprising the step of solidifying successively applied strata of the layer, said contacting steps including applying each next-following stratum subsequent to start of solidification of the immediately preceding stratum.

41. The method of claim 38, wherein successive stages of said bonding step are carried out at predetermined intervals.

42. The method of claim 41, wherein the duration of each of said intervals is between 30 and 120 seconds.

43. The method of claim 38, wherein successive stages of said bonding step are carried out at intervals which are dependent upon the characteristics of the corresponding strata.

44. The method of claim 38, wherein successive stages of said bonding step are carried out at fixed intervals.

45. The method of claim 38, wherein successive stages of said bonding step are carried out at variable intervals.

46. The method of claim 45, wherein the duration of said intervals increases from each preceding stage to the next following stage of said plurality of successive stages.

47. The method of claim 45, wherein the duration of said intervals decreases from each preceding stage to the next following stage of said plurality of successive stages.

48. The method of claim 37, wherein each of said stages includes the application of one and the same material to said film.

49. The method of claim 37, wherein each of said stages includes the application of a different material to said film.

50. The method of claim 49, wherein one of said different materials is a resin and another of said different materials is a wax.

51. The method of claim 50, wherein said stages include at least three successive stages and said bonding step includes alternatingly applying resin and wax during successive stages of said plurality of successive stages.

52. The method of claim 27, wherein said layer contains an organic material and further comprising the step of advancing the substrate along a predetermined path in a predetermined direction and at a predetermined speed, said applying step including vaporizing the metallic material onto the at least one side of the advancing substrate at said predetermined speed in a first portion of said path and said bonding step including establishing

a supply of organic material adjacent a second portion of said path downstream of said first portion, heating the supply to vaporization temperature, and contacting the film with vaporized organic material in said second portion of said path at said predetermined speed.

53. The method of claim 52, wherein said heating step includes electrically heating the supply of organic material.

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Fig. 1

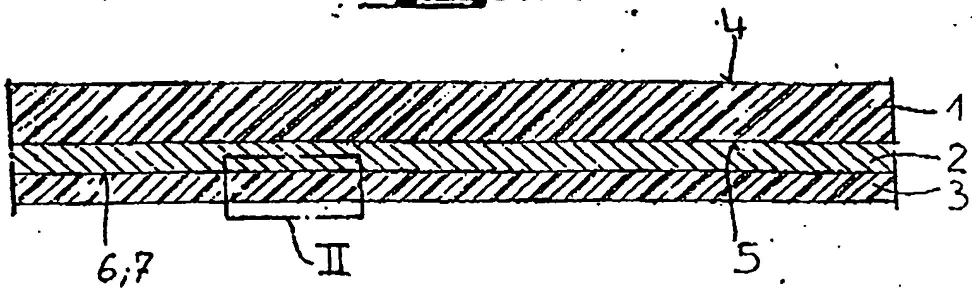



Fig. 2

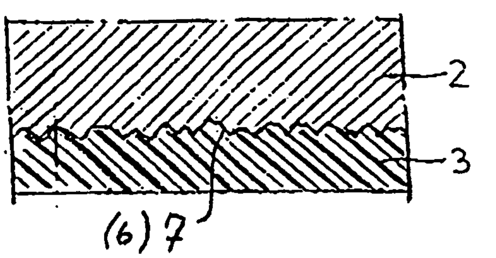
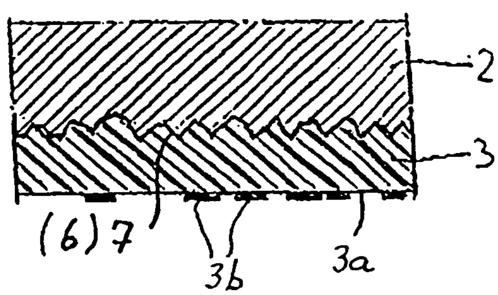



Fig. 3



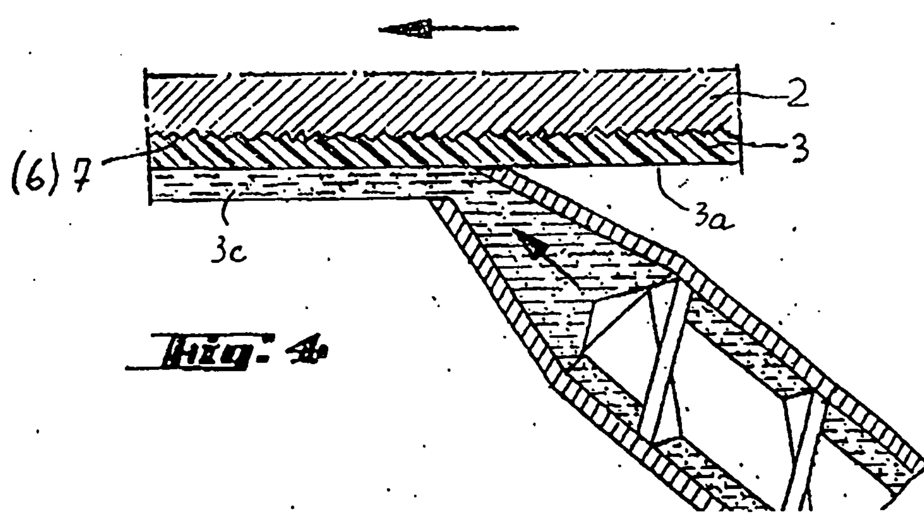




Fig. 4

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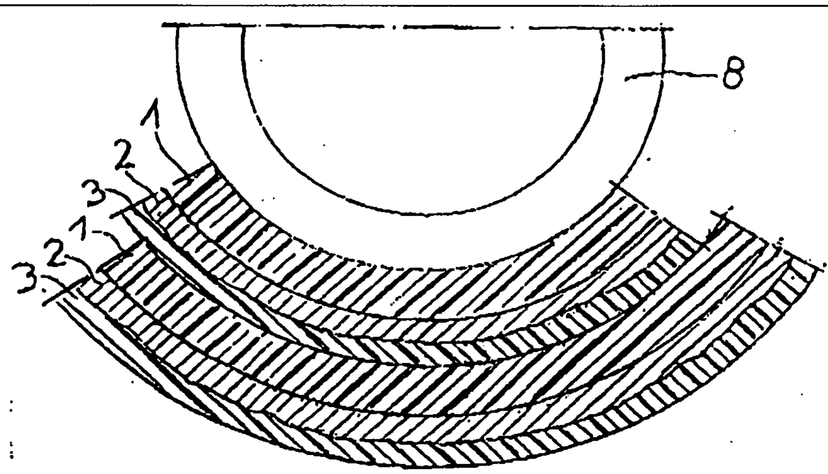
Fig. 5



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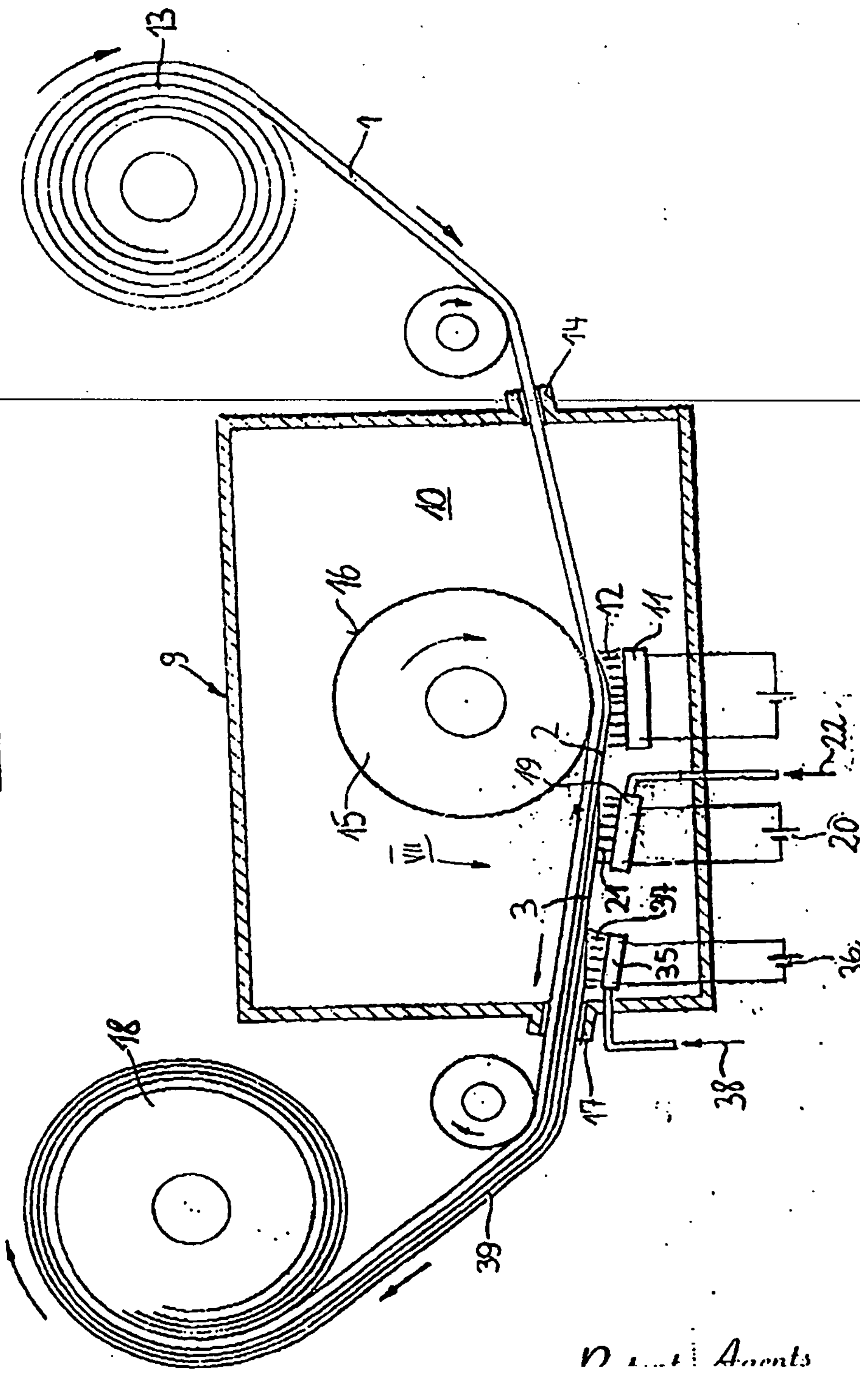


Fig. 6

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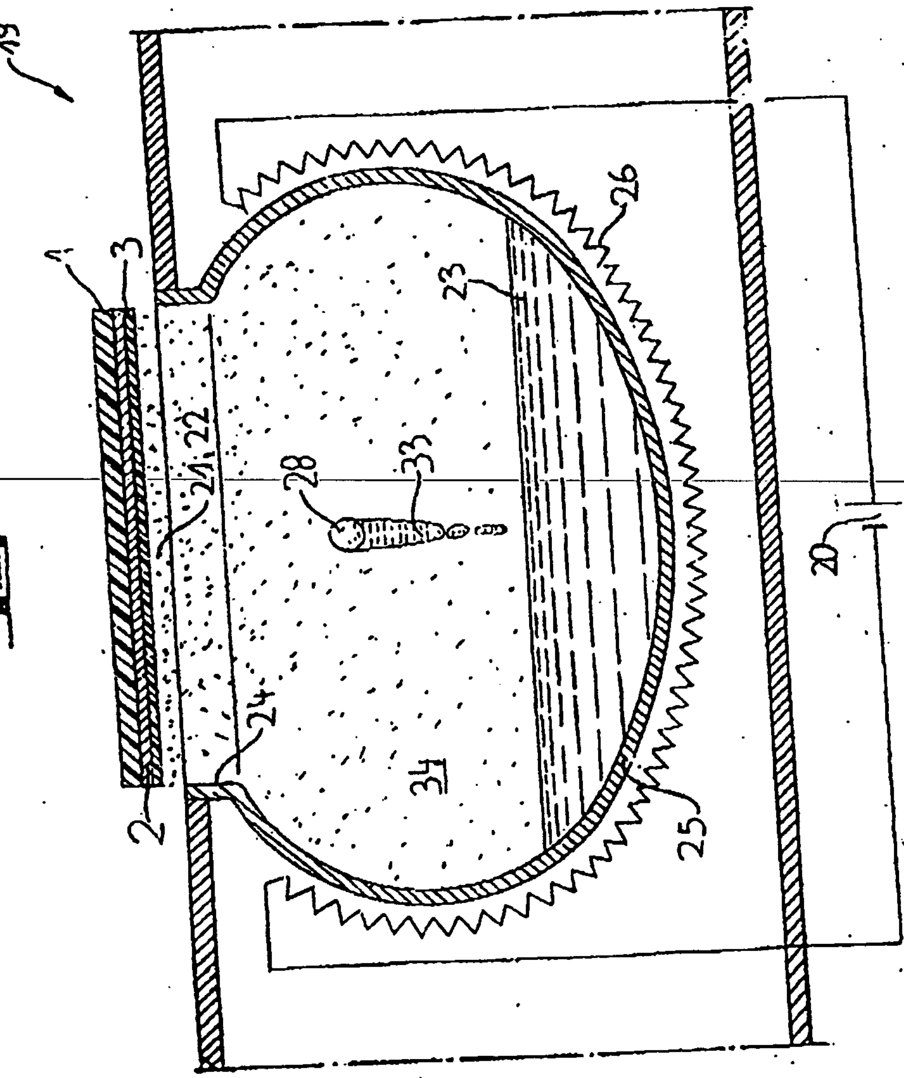


Fig. 2

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